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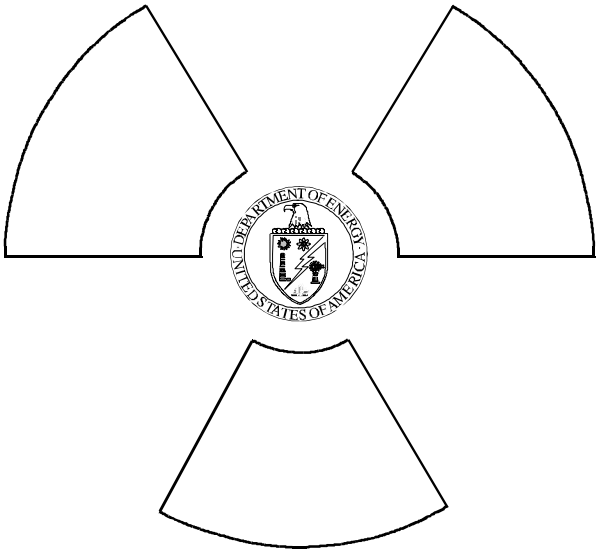
AIR MONITORING GUIDE

for use with

Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection



Assistant Secretary for Environment, Safety and Health

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ACRONYMS

DOE	U.S. Department of Energy
CFR	Code of Federal Regulations
RCS	DOE-STD-1098-99, RADIOLOGICAL CONTROL
ANSI	American National Standards Institute
AEC	U.S. Atomic Energy Commission
DAC	derived air concentration
CAM	continuous air monitor
NRC	U.S. Nuclear Regulatory Commission
ALARA	as low as reasonably achievable
CEDE	committed effective dose equivalent
ALI	annual limit on intake
EPA	U.S. Environmental Protection Agency
NIST	National Institute of Standards and Technology

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AIR MONITORING

1. PURPOSE AND APPLICABILITY

This Guide provides an acceptable methodology for establishing and operating an air monitoring program that will comply with U.S. Department of Energy (DOE) requirements specified in Title 10 of the Code of Federal Regulations (CFR), Part 835, Occupational Radiation Protection (DOE 1998a), hereinafter referred to as 10 CFR 835. For completeness, this Guide cites guidance provided in the DOE-STD-1098-99, RADIOLOGICAL CONTROL (DOE 1999a), hereinafter referred to as the RCS. The Guide also identifies applicable recommendations contained in secondary documents (e.g., American National Standards Institute (ANSI) Standards, etc.).

This Guide is specifically intended to assist the user in fulfilling the air monitoring requirements of 10 CFR 835.209(b)(3), 401, 403, and 603(d). This Guide also provides guidance for the function and operations of an air monitoring program. Monitoring of airborne radioactive effluents, air monitoring under emergency conditions, and the theoretical aspects of air monitoring are not within the scope of this Guide.

This Guide amplifies the regulatory requirements of 10 CFR 835 and provides explanations and examples of the basic requirements for air monitoring. The requirements of 10 CFR 835 are enforceable under the provisions of Sections 223C and 234A of the Atomic Energy Act of 1954, as amended (AEC 1954).

Except for requirements established by a regulation, a contract, or by administrative means, the provisions in this Guide are the DOE's views on acceptable methods of program implementation and are not mandatory. Conformance with this Guide will, however, create an inference of compliance with the related regulatory requirements. Alternate methods that are demonstrated to provide an equivalent or better level of protection are acceptable. DOE encourages its contractors to go beyond the minimum regulatory requirements and to pursue excellence in their programs.

The word "shall" is used in this Guide to designate requirements from 10 CFR 835. Compliance with 10 CFR 835 is mandatory except to the extent an exemption has been granted pursuant to 10 CFR 820, Procedural Rules for DOE Nuclear Activities (DOE 1997a). The words "should" and "may" are used to represent optional program recommendations and allowable alternatives, respectively.

This Guide is applicable to all DOE activities that are subject to the requirements of 10 CFR 835.

2. DEFINITIONS

Terms defined in 10 CFR 835 are used in this Guide consistent with their regulatory definitions.

Air monitoring: Actions to detect and quantify airborne radiological conditions by the collection of an air sample and the subsequent analysis, either in real-time or offline laboratory analysis, of the amount and type of radioactive material present in the atmosphere.

Air sampling: A form of air monitoring in which an air sample is collected and analyzed at a later time, sometimes referred to as retrospective air monitoring.

Alarm set point: The count rate or concentration at which a real-time air monitor will alarm, usually set to correspond to a specific airborne radioactive material concentration averaged over time (e.g., DAC-hour alarm equivalent) by calculating the sample buildup rate on the collection medium.

Breathing zone air monitoring: A form of air monitoring that is used to detect and quantify the radiological conditions of air from the general volume of air breathed by the individual, usually at a height of 1 to 2 meters. See "personal air monitoring."

Continuous air monitor (CAM): An instrument that continuously samples and measures the levels of airborne radioactive material on a "real-time" basis and has alarm capabilities at preset alarm set points.

Fixed-location sampler: An air sampler located at a fixed location in the workplace.

Grab sampling: A single sample removed from the air over a short time interval, typically a few minutes for high volume air samplers and less than one hour for low volume air samplers.

Personal air monitoring: A form of breathing zone air monitoring that involves the sampling of air in the immediate vicinity (typically within one foot) of an individual’s nose and mouth, usually by a portable sampling pump and collection tube (e.g., a lapel sampler) worn on the body.

Portable air sampler: An air sampler designed to be moved from area to area.

Real time air monitor: An instrument that measures the levels of airborne radioactive material on a "real-time" basis.

Representative air sampling: The sampling of airborne radioactive material in a manner such that the sample collected closely approximates both the amount of activity and the physical and chemical properties (e.g., particle size and solubility) of the contaminant to which the individuals may be exposed.

Source-specific air sampling: Collection of an air sample near an actual or likely release point.

3. DISCUSSION

The purposes for conducting an air monitoring program can be characterized as the need to assess individual exposures to airborne radioactive material, determine the need for and prescribe appropriate personnel protection from airborne radioactive material, and provide early warning of unexpected increases in airborne radioactivity levels. The type of air monitoring to be performed will depend on what the monitoring results are needed for. Under 10 CFR 835, air monitoring results are required to measure the concentrations of airborne radioactive material, determine posting requirements, determine the effectiveness of the engineered controls and barriers used to contain and confine radioactive material, determine appropriate protective equipment and measures, and provide warnings of significantly elevated levels of airborne radioactive materials. In addition, air monitoring results may be used to estimate individual intake. 10 CFR 835 establishes the basic elements of an air monitoring program: periodic air samples to assess actual and potential individual exposures and real-time air monitoring to provide immediate warning of increases in airborne radioactive material concentrations.

When implementing an air monitoring program, it is important to achieve a proper balance between the basic elements of the program -- air sampling and real-time air monitoring. The balance will depend on the characteristics of each facility and the justification for the approach taken should be included in program documentation.

The primary difficulty in meeting the air monitoring requirements in 10 CFR 835 is in collecting samples that can reliably reveal and estimate the magnitude of individual exposures. However, it should be possible to reliably detect increases in airborne radioactive material concentrations above baseline levels. This information can be used to initiate bioassay evaluations to verify whether an exposure has occurred and, if so, to estimate the magnitude of the exposure.

Real-time air monitoring is performed to provide warning of significantly elevated levels of airborne radioactive materials. The primary challenge in performing effective real-time air monitoring is placing the monitors where they will provide a rapid and reliable warning that an unexpected release has occurred. The number and placement of real-time air monitors should be optimized. Proper strategy for the placement of real-time air monitors is critical to the effectiveness of the air monitoring program.

The air monitoring program is only one element of a comprehensive radiation protection program. Therefore, individuals involved with the air monitoring program should coordinate their efforts with other radiation protection program personnel, particularly with those involved in contamination control and internal dosimetry.

4. IMPLEMENTATION GUIDANCE

Monitoring of airborne radioactivity is required where an individual is likely to receive an exposure of 40 or more derived air concentration (DAC)-hours in a year or as necessary to characterize the airborne radioactivity hazard where respiratory protective devices for protection against airborne radionuclides have been prescribed (10 CFR 835.403(a)). Real-time air monitoring is required to be performed, as necessary, to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material (10 CFR 835.403(b)).

This section describes acceptable methods for establishing and operating an air monitoring program adequate to demonstrate compliance with 10 CFR 835. The discussion is divided into the following topics:

- determining the need for air monitoring;
- placement of air sampling and real-time air monitoring equipment;
- selection and operation of air sampling equipment;
- selection and operation of real-time air monitoring equipment;
- sample analysis and data review;
- quality control and quality assurance; and
- administrative controls.

NUREG-1400, AIR SAMPLING IN THE WORKPLACE (NRC 1993), was developed by the U.S. Nuclear Regulatory Commission to provide technical information on air sampling for facilities following NRC's related regulatory guidance. The technical information provided in this document is useful for DOE facilities using this Guide. NUREG-1400 contains the following technical information:

- evaluation of the need for air sampling, including air sampling based on potential intakes and concentrations, and air sampling systems;
- location of air samplers, including purpose of airflow studies, determination of airflow patterns, and selecting sample location;
- demonstration that air sampling is representative of inhaled air;
- adjustments to derived air concentrations;
- measurement of the volume of air sampled; and
- evaluation of sampling results, including detecting changes in air concentrations over time, efficiency of collection media, and detection sensitivity.

The previous version of this Guide discussed selected technical information provided in NUREG-1400. This information has been removed from this version of this Guide to avoid redundancy between the two documents. Accordingly, NUREG-1400 should be consulted to obtain pertinent technical information concerning regulatory guidance provided in this Guide.

4.1 DETERMINING THE NEED FOR AIR MONITORING

The decision to perform air monitoring should based on consideration of both actual and potential radiological conditions. Actual conditions are typically confirmed by air sampling results with detectable levels of activity. Potential conditions are identified through the use of professional judgement and experience regarding the likelihood that a radiological condition will exist. When evaluating potential conditions, both normal situations and unusual situations which can reasonably be expected to occur should be considered. NUREG-1400, (Section 1) provides an acceptable methodology for evaluating the need for air sampling by predicting likely intakes for some individuals who might receive a significant intake. This methodology provides an acceptable approach to justify and document decisions based on professional judgement and experience.

4.1.1 Exposure Assessment

Air monitoring through the use of representative sampling is used for the assessment of an individual's exposure to airborne radioactivity. Air monitoring results may be used to determine an individual's type and frequency of bioassay measurements and to estimate an individual's dose from exposure to airborne radioactive material.

Determinations of the need for air sampling should include consideration of occupancy factors to determine if an individual is likely to receive a 40 DAC-hour exposure in a year. For example, if a worker is present in a work area only 200 hours per year and enters no other areas of significant airborne radioactivity, the individual could be exposed to an air concentration just less than 20% of a DAC without receiving an exposure equal to or exceeding 40 DAC-hours in a year.

4.1.1.1 Type and Frequency of Bioassay

10 CFR 835 requires that internal dose monitoring programs be conducted for individuals likely to exceed certain internal dose thresholds (10 CFR 835.402(c)). The air monitoring program can provide significant information for determining the type and frequency of bioassay measurements.

An effective air monitoring program, in combination with an effective and reliable access control program, can facilitate tracking of an individual's exposure to airborne radioactive materials measured in DAC-hours. A DAC-hours tracking program should be considered for DOE activities where individuals could routinely be expected to be exposed to greater than 40 DAC-hours in a year. Internal dose monitoring programs typically assign bioassay frequency and methods based on actual or anticipated individual exposures. Therefore, tracking of individual exposures in DAC-hours can facilitate determination of the type and frequency of required bioassay measurements. For example, if a radiological worker receives greater than 40 DAC-hours in a year, the individual would be required to participate in the bioassay monitoring program. The bioassay frequency and methodology may be determined based on the radionuclides inhaled and the frequency of intakes or exposure to airborne radioactive material.

4.1.1.2 Estimation of Dose

The estimation of internal dose shall be based on bioassay data rather than air concentration values unless bioassay data are:

- unavailable;
- inadequate; or
- internal dose estimates based on air concentration values are demonstrated to be as or more accurate (10 CFR 835.209(b)).

Bioassay data may meet these conditions as a result of instrumentation limitations, sampling discrepancies, or other conditions. DOE G 441.1-3, INTERNAL DOSIMETRY PROGRAM GUIDE (DOE 1999b), provides guidance on evaluation of internal dose from air monitoring data.

If bioassay measurements are not available or their validity is questionable, internal dose estimates can be determined from the number of DAC-hours tracked for that individual. When DAC-hours are used for this purpose, any adjustments, such as protection factors for respiratory protection, shall be documented (10 CFR 835.702(g)). Additional guidance is provided in Guide DOE G 441.1-3.

DOE has addressed the special case where the sensitivity of the bioassay analysis is technologically limited (such as with certain plutonium isotopes). Acceptable methods of dealing with technology shortfalls have been addressed in DOE G 441.1-3 and DOE-STD-1121-98, INTERNAL DOSIMETRY (DOE 1998b).

As required by 10 CFR 835.209(b)(3), when used for determinations of individual dose equivalents, air sampling results must provide dose determinations that are as or more accurate than those provided by bioassay. The air sample should closely approximate both the airborne radioactivity concentration and the physical and chemical properties of the airborne radioactive material. Personal air monitoring is typically used for obtaining air samples that are used for dose determination. DOE G 441.1-3 provides additional guidance for situations where air monitoring is used when there is no practical bioassay method.

Normally, real-time air monitoring should not be used in lieu of air sampling when the results may be used to estimate an individual's dose and intake. The results from real-time air monitoring may not be representative of the air actually breathed by individuals, linked to the individual in that area, or sufficient to use in the estimation of internal dose.

4.1.2 Personnel Protection

Air monitoring is performed to determine the need for “Airborne Radioactivity Area” posting and access controls, evaluate the effectiveness of engineering controls, and determine the proper respiratory protective device.

4.1.2.1 Need for Posting

10 CFR 835.603(d) requires posting of airborne radioactivity areas. Air sampling may be used to determine whether an area should be posted as an airborne radioactivity area. Grab sampling is typically used to determine whether the criteria for posting airborne radioactivity areas have been exceeded. The sample volume should be sufficient to ensure the achievement of adequate counting system detection capabilities.

Guide DOE G 441.1-10, POSTING AND LABELING FOR RADIOLOGICAL CONTROL GUIDE (DOE 1999c), and Chapter 2 of the RCS provide detailed guidance on posting airborne radioactivity areas.

4.1.2.2 Effectiveness of Physical Design Features and Engineering Controls

Physical design features for facilities and systems include measures to preclude and control releases of airborne radioactive material. Air monitoring should be performed in facilities and around systems with physical design features designed to prevent the release of airborne radioactivity and also following modifications which could affect air flow and ventilation balance. Fixed-location air sampling should be considered in the design and modification of facilities where uncontained radioactive material would be used or releases of airborne radioactive material would be anticipated. Results from fixed-location air sampling are particularly useful during the startup of a new facility or new operation within an existing facility to establish baseline airborne radioactive material concentrations and verify containment integrity.

Engineering controls are used to protect individuals when permanent physical design features cannot adequately contain radioactive material. When engineering controls, such as ventilation, vacuum cleaners, or containment devices, are used to reduce or maintain airborne radioactivity concentrations, air monitoring should be performed to determine the adequacy and effectiveness of the engineering controls. Generally, for installed physical design features, such as fume hoods, fixed-location air sampling is preferred, whereas for temporary controls, such as portable ventilation or use of vacuum cleaners, grab sampling is preferred. Real-time air monitoring for determining the adequacy of installed controls may also be appropriate or required. DOE G 441.1-2, OCCUPATIONAL ALARA PROGRAM GUIDE (DOE 1999d), DOE G 441.1-9, RADIOACTIVE CONTAMINATION CONTROL GUIDE (DOE 1999e), and the RCS provide guidance on the use of engineering controls.

4.1.2.3 Proper Respiratory Protective Equipment

Respiratory protective equipment is used to reduce an individual's intake of airborne radioactive materials. Each respiratory protective device is assigned a protection factor that indicates the degree of protection afforded by the respirator. Respiratory protective devices should be chosen based on the protection factor and actual or potential airborne radioactivity levels, taking into account ALARA considerations, other industrial hazards, and worker safety. DOE requires its respiratory protection programs to be conducted in accordance DOE O 440.1A, WORKER PROTECTION MANAGEMENT FOR DOE FEDERAL AND CONTRACTOR EMPLOYEES (DOE 1997b), which endorses the most restrictive of ANSI Z88.2, *Practices for Respiratory Protection* (ANSI 1992) or 29 CFR 1910.134.

An important step in selecting the proper respiratory protective equipment is determining the actual or potential concentration of airborne radioactivity in the area the individual is to enter. Air sampling shall be performed as necessary to characterize the airborne radioactivity hazard where respiratory protection against airborne radionuclides has been prescribed (10 CFR 835.403(a)(2)). Typically, grab sampling is used to determine the airborne radioactivity concentration. Real-time air monitoring may be useful in areas where substantial work is being performed and airborne radioactivity concentrations fluctuate,. If the individual is entering an area where the airborne radioactivity concentration is routinely sampled and is not likely to have changed since air monitoring was last performed, previously obtained samples may be used to characterize the airborne radioactivity hazard. When the need for air monitoring is not clear, historical data from fixed-location air sampling and real-time air monitoring should be analyzed to determine whether respiratory protection is appropriate. NUREG-1400 provides a methodology for predicting the potential intakes which can be useful in determining the need for respiratory protection (Section 1.2).

4.1.3 Early Warning

Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate exposure to airborne radioactive material (10 CFR 835.403(b)). Typically, real-time air monitoring should be used in areas where unexpected increases in airborne radioactivity levels could result in an exposure to an individual exceeding 40 DAC-hours in one week. This exposure is typically representative of a committed effective dose equivalent (CEDE) of approximately 100 millirem. To provide the necessary warning, real-time air monitors should have alarm capability and sufficient sensitivity to detect airborne radioactivity at these levels.

Unlike air sampling, the need for real-time air monitoring is based on the likelihood that an individual will be exposed to an unexpected increase of airborne radioactivity greater than a given level. The use of real-time air monitors is based upon the expectations of discrete events, rather than determination of ambient airborne radioactivity concentrations.

Examples of situations for which real-time air monitoring may be appropriate include the following:

- within or at the boundaries of areas where work is performed that creates or has the potential to create airborne radioactivity;
- within or at the boundaries of areas where a power failure or other disruption of engineering controls could result in the release of airborne radioactivity; and
- within or at the boundaries of established airborne radioactivity areas when work is being performed that has the potential to significantly increase the ambient airborne radioactivity levels.

These examples serve to emphasize that real-time air monitoring is intended to protect individuals both inside and outside of work areas.

Real-time air monitors may not be appropriate or necessary in established airborne radioactivity areas where ambient airborne radioactivity levels are not expected to increase (i.e., unexpected releases are not likely). Grab samples are typically used to monitor airborne radioactivity levels and to detect trends. Historical workplace air monitoring records and knowledge of the type of work to be performed in the area can be used to justify the decision not to use a real-time air monitor.

4.2 PLACEMENT OF AIR SAMPLING AND REAL-TIME AIR MONITORING EQUIPMENT

Once the need for air monitoring has been established, the monitor/sampler location(s) can be determined. Location is important because inappropriately placed equipment may not provide representative results. Concentrations of airborne radioactivity in an area can vary greatly from one location to another.

In general, air sampling equipment is most effective when located close to individuals to provide an indication of airborne radioactivity levels to which they are exposed. Real-time air monitoring equipment should be located to provide an early warning to individuals of a significant increase in levels of airborne radioactive material.

When selecting locations for air sampling and real-time air monitoring equipment, consideration should be given to the locations of possible release points and workers, the purpose of the sample, and room air flow patterns. The cost of real-time monitors and the time required to collect and analyze sample media limit the number used in a facility. This consideration, together with the need for a rapid response to an unplanned release, means that optimal placement is critical. The technical basis for air sampling and real-time air monitoring equipment placement should be documented. The following considerations should be included in technical basis documentation:

4.2.1 Locations of Release Points and Individuals

Actual and potential release points in an area should be identified. Actual release points can be determined from past operating experience. Potential release points can be determined from a review of safety analysis documentation for the facility. The location of individuals in relation to these release points should also be identified. Finally, occupancy times for individuals near the release locations should be estimated.

4.2.2 Purpose of Sample

The purpose of air monitoring is to measure the concentrations of airborne radioactive material to:

- estimate individual intakes;
- determine posting requirements;
- determine the effectiveness of the confinement of radioactive material;
- determine appropriate protective equipment and measures; and
- provide warnings of significantly elevated levels of airborne radioactive materials.

To estimate exposures and intakes, a sample representative of the air breathed by the individual should be taken. The air sampling equipment should be positioned in the vicinity of the individual, taking into consideration the air flow path from likely release points to the individual. Alternatively, if the purpose is to indicate containment or confinement control, then air sampling equipment should be positioned near the release point, or likely release point, in a downstream direction. The downstream direction can be determined by performing air flow studies.

Real-time air monitoring equipment, such as continuous air monitors (CAMs), should be positioned strategically in the affected area or at the affected area boundaries. If there is only one potential release point in an area, then placement of the real-time air monitor as close to the release point as possible in a downwind direction may be adequate. If there are multiple release points and a limited number of real-time air monitors, such that one cannot be placed near each release point, then the real-time air monitors should be placed at locations expected to provide the most reliable indication of a release with the least delay from the onset of the release, should one occur. The general objective is to provide a rapid and reliable warning to the greatest number of individuals that a release has occurred.

4.2.3 Room Air Flow Patterns

Air flow studies should be used to determine the placement of air monitors and facilitate the interpretation of the results of air monitoring. The extent of air flow testing will depend on the type of air monitoring being performed. More extensive air flow testing should be performed when locating fixed-location air samplers and real-time air monitors than when locating air samplers being used as grab samplers for short duration jobs. Air flow studies may be useful in placement of grab samplers to ensure that samples are indeed representative. Air flow testing is not needed for personal air monitoring since proper placement of personal air samplers on the worker ensures collection of representative samples. Acceptable methods for determining air flow patterns are discussed, in detail, in NUREG-1400 (Section 2.3).

The radiation protection organization should be aware of facility characteristics, operations, and changes that may affect airflow patterns. The radiation protection organization should perform and document a review of the adequacy of sampling and monitoring systems periodically and as part of any facility or operational change affecting radiological control. The periodicity of the review should be documented as part of the technical basis for the placement of the air sampling and real-time monitoring equipment.

Placement of fixed-location air sampling and real-time air monitoring equipment should be reevaluated after changes to the ventilation system have been made or after equipment or structures have been added that may influence air flow. Air flow patterns in a given area should be reevaluated no less frequently than every 36 months.

4.3 AIR SAMPLING EQUIPMENT

Types of air sampling equipment include fixed-location air samplers, portable air samplers (high-volume and low-volume), and personal (lapel) air samplers. Selection of air sampling equipment should be based on the type of sample being collected (e.g., breathing zone air sample, source-specific air sample, or grab air sample). Detailed technical information regarding air sampling systems is provided in NUREG-1400 (Section 1.3).

4.3.1 Breathing Zone Air Monitoring

Breathing zone air monitoring should be used when air monitoring results are used to assign internal doses and when determining the effectiveness of respiratory protection equipment. Breathing zone air monitoring involves collecting an air sample from the individual's breathing environment, making allowances to eliminate interferences the samplers themselves may have on the individual's activities. Such air samples provide the most reliable indicator of the potential for inhalation of airborne radioactivity and can provide an estimate of the magnitude of possible exposures. Breathing zone air samples can be collected using fixed-location air samplers, portable air samplers, or personal air samplers. When fixed-location air sampling equipment will not provide a representative indication of the individual's breathing zone, then personal air sampling equipment should be used. When using personal air samplers, the radiation protection staff should ensure that the low flow rate will allow collection of enough radioactive material to meet the minimum sensitivity requirement for air monitoring.

Breathing zone air monitoring should also be used in areas where workers are likely to exceed an exposure of 40 DAC-hours in a year, and to identify possible worker internal exposures and the need for followup bioassay measurements. Breathing zone air monitoring data may be used to estimate intakes of radioactive material and subsequent internal dose in accordance with the requirements of 10 CFR 835.209(b).

4.3.2 Source-Specific Air Sampling

Source-specific air sampling is the collection of an air sample near an actual, or likely, release point in a work area. Fixed-location and portable air samplers can be used for source-specific air sampling to verify containment or confinement integrity, document airborne radioactive material levels (can be used for determining the need for posting), and provide information relevant to determining when the use of respiratory protective devices is necessary.

4.3.3 Grab Sampling

Grab sampling should be used for temporary or non-routine situations and as a backup for other types of air sampling in the event of equipment failure. Grab sampling can be used to determine whether areas should be posted as airborne radioactivity areas and respiratory protective devices should be used for protection against airborne radioactive material. Portable air sampling equipment should be used for operations requiring grab sampling. Sample flow rates may vary depending upon the specific application, but should always allow collection of a sample volume adequate to ensure that the minimum detectable activity of the sampling and counting system corresponds to an intake of no greater than 2% of an annual limit on intake (ALI) ALI and 10% of the appropriate DAC.

4.3.4 Operability Checks

Operability checks of air monitoring equipment are used to ensure that the equipment is functioning properly prior to and during use. Operability checks shall be performed routinely on flow rate meters (10 CFR 835.401(b)(4)). In addition, because excessive dust loading interferes with alpha particle detection and reductions in flow rate result in uncertainties in the total air volume sampled, periodic verification of flow rates should be performed. At a minimum, the flow rates should be verified when sample media are exchanged. Rapid or significant changes in

flow rate should be investigated immediately. These instances may indicate the need for more frequent changes of sample media or loss of integrity of filter or sampling equipment. The sample flow rate used for estimating air concentration should be the average of the flow rate when the sample was started and the flow rate when the sample medium was removed.

4.4 REAL-TIME AIR MONITORING EQUIPMENT

4.4.1 Instrument Selection

Instruments used for real-time air monitoring shall be appropriate for the type(s), levels, and energies of radiation(s) encountered in the workplace (10 CFR 835.401(b)(2)) and for existing environmental conditions (10 CFR 835.401(b)(3)). The selection of real-time air monitors should be based on the characteristics of the airborne radioactive material, the anticipated range of airborne radioactive material concentrations and the possible variations of the concentrations over time. The type of real-time air monitor used depends on the type of facility in which it is used, the radioisotopes being monitored, and the physical and chemical forms of the radioactive material. Commonly used monitors at DOE facilities are: particulate-radioactive material continuous air monitors (e.g., alpha CAMs and beta CAMs); impactor air monitors; and gaseous radioactive material monitors. Monitors that use background-reduction methods (e.g., activity-fractioning monitors and pseudo-coincidence monitors) may also be used. CAMs should not be used when high levels of contamination or other factors would prevent them from providing reliable results. Use of CAMs for particulates and noble gases is acceptable; however, detection of radon requires a different monitoring methodology that provides real-time information and alarm capabilities. In these cases, the use of working level monitors may be acceptable.

If a real-time air monitor is likely to become highly contaminated or if unreasonably high flow rates are needed, then one of the following techniques can be used: (1) periodic direct reading of fixed air sample media by using portable survey instruments; or (2) periodic grab samples with rapid analysis.

4.4.2 Alarm Set Points

Real-time air monitors should be capable of measuring 1 DAC when averaged over 8 hours (8 DAC-hours) under laboratory conditions. Alarm set points for real-time air monitors used for routine monitoring should be set at the lowest practical level so as to accurately indicate loss of containment or the need for corrective action without causing a significant number of false alarms. When monitoring for alpha emitters shows high radon and thoron concentrations, an alarm set point of up to 24 DAC-hours may be acceptable. In all cases, the actual alarm set point established for each unit and the technical basis for the alarm set points should be documented. If real-time monitors are used during work requiring the use of respiratory protective devices, the alarm set point can be adjusted to provide an early warning that the applicable respiratory protection factor may be exceeded.

4.4.3 Alarm Capabilities

Real-time air monitors shall have alarm capability and sufficient sensitivity to alert potentially exposed individuals that immediate action is necessary to minimize or terminate inhalation exposure (10 CFR 835.403(b)). The alarm should be audible and have a distinctive tone or sound so that it is not confused with other work area alarms, such as those for criticality. The audible alarm intensity should be a minimum sound level of 75 dB at 15 cm. In areas that have a high ambient noise level (>95 dB), a visual alarm should activate with the audible alarm. The visual alarm should be distinctive so that it cannot be mistaken for other types of alarms. If the monitor is installed outside the work area, there should be additional audible and visible alarm indicators inside the area to ensure that individuals are promptly notified. ANSI N42.17B, *Performance Specifications for Health Physics Instrumentation - Occupational Airborne Radioactivity Monitoring Instrumentation* (ANSI 1989), provides additional guidance regarding alarm capabilities.

4.4.4 Operability Checks

Operability checks shall be routinely performed on real-time air monitoring equipment (10 CFR 835.401(b)(4)). The following periodic operability checks should be performed at the frequency indicated:

- Daily operability checks should include positive airflow indication, presence of a typical non-zero response to background activity, and internal check sources or 60 Hz electronic checks when available. In addition, daily checks should verify the control settings and the operability of strip chart recorders, if used.

- Weekly operability checks should verify instrument response with a check source or with ambient levels of radon or thoron daughters. If an instrument response falls outside established response limits, it should be taken out of service.

- Once each month, every real-time air monitor in active service should be tested to ensure proper operation of the alarm. Alarm testing should also verify alarm response when the detector fails.

The adequacy of battery power should be tested monthly for real-time air monitors that rely on battery backup power in an emergency. Similarly, for those monitors using emergency power supplies, the adequacy of the emergency power for monitor operation should be verified as a part of the emergency power checks.

4.5. SAMPLE ANALYSIS AND DATA REVIEW

Provisions for detecting changes in radiological conditions, detecting the gradual buildup of radioactive material, verifying the effectiveness of engineering and process controls in containing radioactive material, and identifying and controlling potential sources of individual exposure to radioactive material require that certain evaluations of air monitoring results be performed (10 CFR 835.401(a)(3-6)). Additional technical information regarding evaluation of sampling results is provided in NUREG-1400 (Section 6).

Air sample results should be evaluated as quickly as practical for special situations, such as the evaluation of the need for respiratory protection, area evacuation (if necessary), individual intake, and relief from use of respiratory protective devices. Preliminary assessments of air samples using field survey techniques should be performed promptly upon removing the sample from its holder. When background levels of radon and thoron daughters interfere with evaluation of alpha air samples, prompt field assessments may not be possible. Procedures should define the methods for counting samples in the field (i.e., detection equipment to use, configuration of the detector and the sample, and conversion factors). Prompt field assessments are not required for fixed-location, portable, or personal air samplers used to routinely sample the individual's breathing environment unless upset conditions have been identified.

Appendix A of 10 CFR 835 has a provision that allows the adjustment of DACs to reflect the actual physical characteristics (e.g., particle size) and chemical characteristics (e.g., solubility in lung fluid) of the airborne radioactive material. Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake And Air Concentration and Dose Conversion Factors For Inhalation, Submersion, and Ingestion* (EPA 1988), should be used when determining the retention class for the chemical compound of the radionuclide taken into the body. Guidance on making adjustments to DACs can be found in NUREG-1400 (Section 4), and in DOE STD-1121-98.

4.6 QUALITY CONTROL AND QUALITY ASSURANCE

Records of the results of air monitoring shall be documented and maintained (10 CFR 835.703(a)). To meet this requirement, quality control should be applied to all phases of the air monitoring program to include sample identification, handling, and storage, air sampling and real-time air monitoring equipment, counting room equipment, and record-keeping.

4.6.1 Sample Identification, Handling, and Storage

All samples collected should be assigned an identification number that cannot be confused with samples taken at another location. Sample designators should be placed on all collection envelopes or containers to reduce the possibility of mislabeling a sample. Other information on the envelope should include the date and time of sample collection and the sample flow rates.

Samples should be handled carefully to prevent cross-contamination between samples and should be placed in appropriately labeled containers to reduce the potential for loss. Arrangements should be made for sample storage prior to counting and between counts if multiple counts are required.

Each organization should develop a tracking system for its air samples that permits positive identification of any individual sample, while indicating the results of the sample analysis, the flow rate, the dates and times of sample collection, the individual performing the collection, and pertinent information about the sample collection system. A sample log book or a computerized database should be maintained. This should contain the necessary entries to provide a complete history of the sample and its analysis.

4.6.2 Air Sampling and Real-Time Air Monitoring Equipment

Components of air sampling and real-time air monitoring systems (i.e., air mover, CAM detector, portable air sampler, fixed sampling head, sampling line) should be uniquely identified. Labeling of equipment and maintaining a log of equipment locations will allow the radiation protection staff to locate a sampling or monitoring unit should there be a questionable sample result.

Equipment used for air monitoring shall be periodically maintained and calibrated on an established frequency (10 CFR 835.401(b)(1)). ANSI N42.17B indicates that air flow meters, differential pressure indicators, and other devices used to determine volumetric flow rates of air samplers and monitors should be calibrated to within $\pm$15% of the true reading. Calibrations should be performed annually at the atmospheric pressure and temperature conditions that are expected during sampling conditions, or the appropriate correction factor should be applied during the calculation of the flow rate.

Detectors in real-time air monitors should be calibrated with a calibration source(s) typical of the radionuclide(s) present in the work environment. The calibration should also be performed after failure of an operability test. Calibration sources should be traceable to the National Institute of Standards and Technology (NIST).

At a minimum, air inleakage tests should be performed on real-time air monitors when they are calibrated, whenever a monitor is replaced, and whenever a monitor's rubber O-rings or other seals are replaced. Ideally, tests for inleakage should also be performed during monthly or quarterly performance tests. Care should be exercised to prevent equipment damage during testing. For example, rapid changes in sample line pressure on some real-time air monitors may damage the detector.

Procedures should be established to address the appropriate review and use of data when a critical component of an air monitoring system (e.g., detector or airflow meter) is determined to be out of calibration. Procedures should be established to review the accuracy of any data generated by that particular equipment since it was last calibrated.

4.6.3 Counting Room Equipment

Counting room equipment shall be routinely tested for operability (10 CFR 835.401(b)(4)). Daily performance checks of background count rate and radiation response (source checks) should be performed on the counting system.

4.6.4 Audits

The radiation protection organization should perform and document a review of the adequacy of air monitoring systems as part of any facility or operational changes affecting radiological control. In the absence of such changes, a review should be conducted annually. The air monitoring program should be reviewed as a functional element in the internal audit program required under 10 CFR 835.102.

4.6.5 Recordkeeping

10 CFR 835 establishes specific requirements for the documentation of air monitoring. Guide DOE G 441.1-11, OCCUPATIONAL RADIATION PROTECTION RECORD-KEEPING AND REPORTING GUIDE (DOE 1999f), and the RCS discuss these requirements and provide detailed guidance.

4.7 ADMINISTRATIVE CONTROLS

4.7.1 Technical Basis Document

A document should be developed that provides the technical basis for selecting, placing, and operating air sampling and real-time air monitoring equipment. This document should include information such as:

- performance and acceptance testing of new equipment;
- filter media characteristics;
- sample transport line losses (if applicable);
- flow rate and duration of sample collection;
- identification of relevant supplies and equipment by manufacturer, make, and model;
- performance of air flow studies;
- rationale for the use and placement of air samplers and real-time air monitors;
- rationale for demonstrating that air samples are representative of air breathed by workers;
- list of, and a facility map showing, actual locations of air sampling and real-time air monitoring equipment;
- calculation of the decision level, minimum detectable activity, and minimum detectable concentration for sampling/counting configurations;
- procedures for sample analysis;
- procedures for sample accountability; and
- routine maintenance and calibration of equipment.

This information should be readily available to radiation protection staff and should be reviewed periodically and revised as necessary.

4.7.2 Written Procedures

Written procedures should be available for:

- collecting air samples;
- performing operability checks of air sampling and real-time air monitoring equipment;
- calibrating flow rate meters;
- calibrating any radiation detectors that are part of the air monitoring equipment;
- conducting air flow studies to aid in the placement of air sampling and real-time air monitoring equipment; and
- interpreting the air monitoring results.

Other written procedures should be established for the following:

- counting room staff, on the operation and routine maintenance of air sample counting equipment, including the development and continued use of source count statistical control charts.
- radiochemistry staff, on the performance of special analyses.

Any changes in procedures used for monitoring in the workplace shall be documented (10 CFR 835.704(e)).

5. REFERENCES

AEC (U.S. Atomic Energy Commission) 1954. Atomic Energy Act of 1954, as amended. Public Law 83-703 (68 Stat. 919), Title 42 U.S.C. sec. 2011.

ANSI (American National Standards Institute) 1989. ANSI N42.17B, *Performance Specifications for Health Physics Instrumentation - Occupational Airborne Radioactivity Monitoring Instrumentation*. New York, New York.

ANSI 1992. ANSI Z88.2, *Practices for Respiratory Protection*. New York, New York.

DOE (U.S. Department of Energy) 1997a. 10 CFR 820, U.S. Department of Energy, Procedural Rules for DOE Nuclear Activities. 58 FR 43680, *Federal Register*, Vol. 58, No. 157, dated 10-8-97. Washington, D.C.

DOE 1997b. DOE O 440.1A, WORKER PROTECTION MANAGEMENT FOR DOE FEDERAL AND CONTRACTOR EMPLOYEES. Washington, D.C.

DOE 1998a. 10 CFR 835, U.S. Department of Energy, Occupational Radiation Protection. 63 FR 59662. *Federal Register* Vol. 63, No. 213, dated 11-4-98. Washington, D.C.

DOE 1998b. DOE STD-1121-98, INTERNAL DOSIMETRY, under development at time of publication. Washington, D.C.

DOE 1999a. DOE-STD-1098-99, RADIOLOGICAL CONTROL, under development at time of publication. Washington, D.C.

DOE 1999b. DOE G 441.1-3, INTERNAL DOSIMETRY PROGRAM GUIDE, dated 3-17-99. Washington, D.C.

DOE 1999c. DOE G 441.1-10, POSTING AND LABELING FOR RADIOLOGICAL CONTROL GUIDE, under development at time of publication. Washington, D.C.

DOE 1999d. DOE G 441.1-2, OCCUPATIONAL ALARA PROGRAM GUIDE, dated 3-17-99. Washington, D.C.

DOE 1999e. DOE G 441.1-9, RADIOACTIVE CONTAMINATION CONTROL GUIDE, under development at time of publication. Washington, D.C.

DOE 1999f. DOE G 441.1-11, OCCUPATIONAL RADIATION PROTECTION RECORD-KEEPING AND REPORTING GUIDE, under development at time of publication. Washington, D.C.

EPA (U.S. Environmental Protection Agency) 1988. Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake And Air Concentration and Dose Conversion Factors For Inhalation, Submersion, and Ingestion*. Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission) 1993. NUREG-1400, Rev. 1, AIR SAMPLING IN THE WORKPLACE. Washington, D.C.

6. SUPPORTING DOCUMENTS

American National Standards Institute. ANSI N13.1-1969(R1993), *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities*. New York, New York. 1993.

American National Standards Institute. ANSI N317-1980(R1991), *Performance Criteria for Instrumentation Used for Inplant Plutonium Monitoring*. New York, New York. 1991

International Commission on Radiological Protection. ICRP Publication 23, *Report of the Task Group on Reference Man*. Pergamon Press, New York, New York. 1975

U.S. Nuclear Regulatory Commission. Regulatory Guide 8.25, AIR SAMPLING IN THE WORKPLACE. Washington, D.C. 1992.

UNITED STATES
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Request for Changes to
WORKPLACE AIR MONITORING GUIDE

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Page No. _____	Facility Requesting Change:_____
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Description of Change Request:

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